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DESIRED VERSUS REALIZED BENEFITS OF ALTERNATIVE CONTRACTING METHODS ON EXTREME VALUE HIGHWAY PROJECTS

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Highway agencies choose alternative contracting methods (ACMs) to for a wide variety of reasons, primarily their potential for superior cost and schedule performance. Most literature focuses on these two factors by analyzing aggregate datasets covering a wide-ranging contract values. These analyses create two voids that this paper attempts to explore: (1) ACMs provide a wide variety of benefits, which cost and schedule performance alone do not identify; and (2) projects of differing contract values benefit differently. This paper investigates the selection criteria for ACMs and why US agencies chose ACMs for projects at the extreme ends of the cost spectrum (defined as projects at the upper and lower 10th percentiles for each delivery method) and what benefits are realized, above and beyond cost and schedule performance. These findings are presented through a survey of 291 US projects, interviews of sixteen US agency representatives, literature review, agency ACM manual content analysis.

Keywords: Decision variables, Performance.

1 INTRODUCTION

Highway agencies choose alternative contracting methods (ACM) to save time and control costs. Several studies have found that ACMs have shorter project durations method (Konchar and Sanvido 1998, AECOM 2003, Hale *et al.* 2009, Carpenter and Bausman 2016) and lower cost growth (Konchar and Sanvido 1998, Warne 2005, Shrestha *et al.* 2007, Hale *et al*. 2009) than the traditional design-bid-build (D-B-B) contracting method. These studies rely on aggregate datasets covering a wide range of contract execution values. This approach has created two voids that this paper attempts to explore: (1) ACMs provide a wide variety of benefits; and (2) projects of differing contract values benefit differently. This research reports on a sample of 291 D-B-B, design-build (D-B), and construction manager/general contractor (CM/GC) highway projects completed between 2004 and 2015 analyzing the dataset in categories of extreme project values (defined as projects at the upper and lower 10th percentiles for each delivery method).

D-B-B is the traditional, and most commonly-used highway delivery method. CM/GC and D-B are the two most commonly-used ACMs over the last 15 years in the United States (US). With D-B-B, the agency separates engineering and construction and bears the full design risk. D-B-B is the preferred method for projects of low complexity and risk (AECOM 2003). In CM/GC, the owner contracts with a construction manager (CM) early in the design development. An agreed

upon price is negotiated for construction services with the CM, at which point the CM becomes the general contractor (GC), hence CM/GC. CM/GC is well-suited for high risk, complex projects and is frequently chosen due to monetary project size and budgetary control concerns (Gransberg and Shane 2010). In D-B, the agency contract with a single entity to perform both design and construction services. D-B procurement can be low bid, best value, or qualifications based. D-B suitability is thought to be strongly correlated to project size and complexity (AECOM 2003).

Previous research findings suggest that agencies find CM/GC and D-B most suitable for large highway projects (AECOM 2003, Gransberg 2010). This is supported by the use of ACM on the $1.8 billion California Foothill/Eastern Transportation Corridor, $1.4 billion Utah I-15, and the $1.7 billion Colorado T REX high profile, mega-projects. The recently enacted Caltrans ACM legislation supports this as all CM/GC projects are over $50 million in value, and average D-B project size is over $211 million. In these cases, agencies chose ACMs to reduce construction costs by sharing project risks, achieve higher quality through contractor innovation, and accelerate schedule by overlapping design and construction (Smith 1995, Warne and Downs 199, FHWA 2007). Empirical findings on large D-B projects have shown cost growths of 2% to 4% and schedule growths from -11% to 11%, in comparison to the traditional D-B-B cost growth of 13% and schedule growth of 4% (Warne 2005, Shrestha 2007). Alternative to the above, a recent FHWA study found that, for projects completed through 2004-2015, agencies are using ACMs equally on both projects under $20 million and over $20 million with equivalent cost performances (Alleman *et al*. 2016). Empirical findings on small D-B projects have shown cost growths of -2% to 6% and schedule growths from -36% to -4%, small CM/GC projects having cost growth of 2%, and D-B-B having a cost growth of 3% to 11% and schedule growth of 5% to 34% (Gransberg *et al*. 2000, FHWA 2006, Alleman *et al*. 2016).

2 DATA COLLECTION AND METHOD OF ANALYSIS

Data for this paper involves a database of project performance, review of agency operational manuals and interviews with project managers. The database used for this paper is part of a national study on the risks and benefits of ACMs for highway construction. This study collected performance data from 291 US highway projects completed between 2004 and 2015. These projects were collected from 28 public agencies who use traditional and ACM delivery. Data was obtained through agency contract databases and project representative questionnaires. This study defines the project extremes as the projects within the lowest, P(.10), and highest. P(.90), 10th percentiles from this database for each delivery method, as follows: 1) **D-B-B Extreme:** Small [P(.10)] = $1.2M and Large [P(.90)] = $42.4M; 2) **CM/GC Extreme:** Small [P(.10)] = $1.9M and Large [P(.90)] = $79.8M; and 3) **D-B Extreme:** Small [P(.10)] = $1.9M; Large [P(.90)] = $120.8M. Cost growth and award growth are calculated using the following equations Eq. (1) and (2):

$$\text{Cost Growth} = (\text{Final Contract Cost} - \text{Contract Award Cost}) / (\text{Contract Award Cost}) \quad (1)$$

$$\text{Award Growth} = (\text{Contract Award Cost} - \text{Engineer's Estimate}) / (\text{Engineer's Estimate}) \quad (2)$$

Twenty-five states were identified with manuals, see Table 1.

Table 1. State DOTs with manuals related to ACMs.

Manuals	AK	AZ	AR	CA	CO	DC	FL	GA	ID	IL	LA	MD	MA	MI	MN	MO	MT	NV	NY	NC	OH	OR	PA	SC	SD	TN	TX	UT	VT	VA	WA	WV
D-B	•	•	•	•	•	•	*	•	•	•	•	•	•		•	*	•		•	•	•	*		*	*	•	*	•	•	•	•	*
CM/GC		•			•																							•				
ACM				•	•									•	•			•					•									

The researchers interviewed project representatives from five D-B extreme small projects, three from D-B small projects, three from CM/GC extreme small projects, three from D-B extreme large projects, and two from extreme large CM/GC projects. Agency representatives were asked about performance, delivery method, and the benefits/hardships of the project.

3 FINDINGS

From the findings, Table 2 and 3 are the Cost and Award Growth by size and delivery type.

Figures 1 (a) and 1 (b) depict the design, procurement, construction, and overall comparison durations of D-B-B, CM/GC, and D-B for extreme projects. To have like-sized projects, extreme small projects are projects smaller than $2M and extreme large projects are larger than $5M.

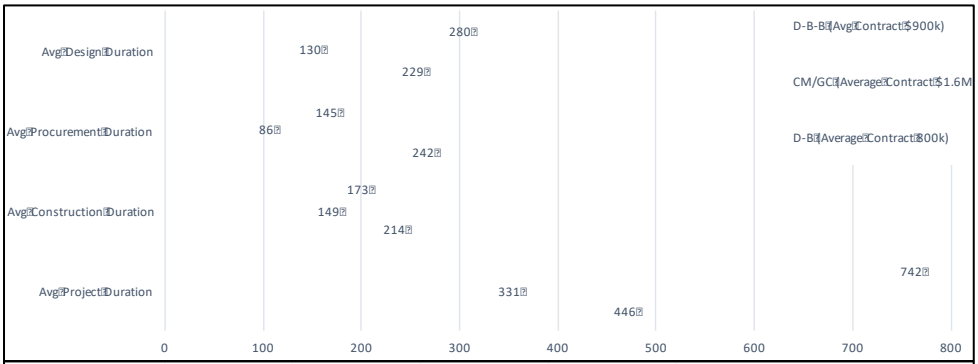
Table 2. Small, mid-sized, and large average cost growth by delivery type.

Delivery Method	Extreme Small		Mid-Sized		Extreme Large	
	N	Cost Growth	N	Cost Growth	N	Cost Growth
D-B-B	13	-0.67%	106	5.47%	13	8.65%
CM/GC	3	1.89%	28	4.81%	3	1.10%
D-B	12	2.47%	98	4.99%	12	5.91%

Table 3. Small, mid-sized, and large average award growth by delivery type.

Delivery Method	Extreme Small		Mid-Sized		Extreme Large	
	N	Cost Growth	N	Cost Growth	N	Cost Growth
D-B-B	13	-13.32%	103	-7.65%	13	45.64%
CM/GC	3	0.54%	28	7.34%	3	3.19%
D-B	12	-12.66%	92	-5.39%	10	-5.82%

a)



b)

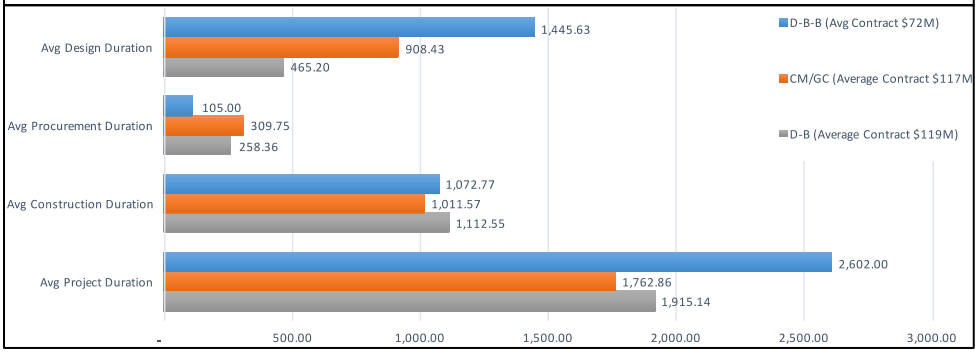


Figure 1. Average durations (calendar days) for (a) Extreme small projects and (b) Extreme large projects.

The agency manual content analysis revealed a range of project delivery selection criteria as shown in Table 4. The level of detail provided in manuals varies. Guidelines help agencies analyze their projects per issues relevant to delivery method selection, but do not dictate specific decisions. Colorado has the most developed processes for selecting a delivery method, including a project delivery selection matrix and workshop for delivery method selection (CDOT 2007).

Table 4. Selection criteria from state ACM manuals.

		GM/GC		D-B																	ACMs				
Count	Decision Description	AZ	CO	AK	AZ	AR	CO	DC	FL	GA	ID	LA	MD	MN	MO	NY	NC	OH	OR	VA	WA	CA	CO	MI	NV	PA
24	Delivery Schedule (including emergencies)	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
21	Complexity and innovation		•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	
16	Project risk assessment		•	•		•	•	•	•	•	•		•	•			•		•	•	•		•		•	
13	Owner staff experience and availability	•	•		•		•	•			•	•						•	•		•	•	•	•		
11	Project cost		•				•	•				•	•			•	•			•		•	•		•	
10	Competition and contractor experience	•	•		•		•	•			•									•			•	•		•
10	Traffic management			•		•		•					•		•	•	•				•			•		•
10	Third-party coordination; permitting				•			•	•		•	•	•			•	•	•	•							
9	Ability to define project requirements				•	•			•			•	•			•		•		•						•
6	Funding	•		•	•			•					•			•										
6	Level of design		•				•				•		•			•							•			
5	Project quality; control of quality				•			•											•		•					•
4	Flexibility											•	•		•	•										
4	Level of oversight and control		•				•												•				•			
3	Work zone/construction safety issues																•							•		•
1	Consistent work, variable locations																							•		
1	Constructability																•									

Songer *et al.* (1996) found the decision variables for choosing D-B, from greatest to least, include: acceleration, budget certainty, cost savings, innovation, decrease litigation, schedule certainty, and project size. The top advantages for CM/GC per existing literature from most prominent to least: contractor innovation, schedule acceleration, early cost certainty, work packaging, design ownership, construction cost control, and reduced design cost (Gransberg and Shane 2010).

Interviews revealed ACM benefits projects of extreme values. Extreme small D-B projects benefits, in addition to those for large projects, include: expedited construction start, experience for small D-B firms, and project warranties. Most of the interviewees stated that the potential benefits of D-B were not different between small and large projects: acceleration, innovation, and risk transfer. Extreme large D-B projects agency interviews cited project acceleration, contractor innovation, and owner's opportunity to add value while maintaining budget. Extreme large and small CM/GC projects had very similar benefits, except that some agency representatives stated that benefits of small CM/GC were not worth the inclusion of preconstruction fees and should be delivered through D-B-B. Contractor involvement and collaboration was a cited benefit of CM/GC and lead to better constructability, value-engineering, accelerated project schedules, better cost management and less cost growth, and earlier cost certainty.

4 DISCUSSION

The desired benefits of D-B projects of extreme large are as expected through previous literature of the benefits of D-B: schedule acceleration, contractor innovation, cost savings, and risk transfer. The high-profile use of D B on mega-projects may indicate that extreme large projects are the type of projects agencies think of as suitable for D-B. As such, agencies would expect to have shorter project schedules; receive innovative, more cost-efficient proposals, and have low construction cost growth. Agencies expect these savings to be magnified on large projects.

Table 5. Realized benefits of ACMs.

Desired Benefit	Realized Benefit
	Extreme Large D-B Projects
Schedule Acceleration	**Yes -** Figure 1 clearly shows D-B as having an accelerated overall project duration due to the accelerated design duration. However, we do see that this benefit is muted on extreme large projects (38%) versus the extreme small project (66%) time savings.
Innovation	**Yes –** Agency representatives confirmed they were receiving innovative ideas, especially when ATCs where part of the procurement process. They stated innovative ideas where generally small in magnitude, but Table 3 shows D-B receiving greater award savings, perhaps due to innovation.
Cost Savings	**Potentially –** Table 2 seems to depict that D-B extreme large projects have the greatest cost growth. However, Table 3 shows nearly equal savings. The FHWA study found that D-B incurred many value-adding change orders. Table 2 growth may be spending of Table 3 savings and value-adding.
Risk Transfer	**Yes** – D-B inherently transfers risk to the D-B contractor. Agency representatives confirmed this in interviews concerning the lack design types of change orders as risk had been transferred.
	Extreme Small D-B Projects
Project Start Acceleration	**Potentially** – Though not empirically proven through our data, almost all agency representatives interviewed stated this was realized on their D-B project. However, the combined design/procurement time of D-B in Figure 1 is longer than the D-B-B combined duration.
Risk Transfer	**Potentially** – The risk transfer occurred more in the ability to warranty the work through several years of the maintenance period. However, this was only cited by one agency representative.
Contractor Experience	**Potentially** – Agency representatives stated having smaller contractor firms gaining D-B experience. This was cited by two agency representatives as a possibility, but difficult to confirm.
Same as Large Projects	**Yes** – The extreme small D-B projects seem to have greater cost savings, as seen in Tables 2 and 3, and a greater schedule acceleration than extreme large projects.
	Extreme Large CM/GC Projects
Contractor Innovation	**Yes** – Cost growth is better than D-B and D-B-B and greater than lessor valued CM/GC projects. Innovation was also claimed as a benefit in all agency representative interviews.
Schedule Acceleration	**Yes -** Figure 1 clearly shows CM/GC as having an accelerated overall project duration. This benefit is muted on extreme large projects (32%) versus the extreme small project (55%) time savings.
Cost Control	**Yes** – The FHWA study found that CM/GC had the least variance in award growth, and therefore the most consistently accurate. Table 2 depicts cost growth as being much less than D-B-B. Finally, agencies claimed cost control through the relationship gained with contractor.
Cost Certainty	**Yes** – Figure 2 shows the design duration to be much less than D-B-B. This means that cost certainty is gained sooner. Interview findings were that bringing on an Independent Cost Estimator and having them perform estimates early in the preliminary design gave greater cost certainty.
	Extreme Small CM/GC Projects
Managerial Expertise	**Potentially** – Gransberg and Shane (2010) cite early contractor involvement as a benefit of CM/GC and two agency representatives stated this as a benefit.

The agency manual content analysis and previous literature shows no difference in decision variables for extreme large and extreme small D-B projects. In this study, the authors found that agencies are expecting additional benefits on small projects. Beyond the desired schedule acceleration and mitigated cost growth, agency representatives desired expedited project start, life-cycle risk transfer through warranties, and contractor experience gained from extreme small D-B projects. Often in the extreme small D-B projects innovation was not desired at all, agencies desired D-B's ability to "get the job on the street" which allowed for jobs which impacted public safety or received time-dependent funding to benefit from the minimal design requirements. Other times, even the schedule acceleration was not desired, but rather operations risk transfer using warranties which were a benefit of D-B not allowed with D-B-B.

Agencies' desired benefits from extreme large CM/GC were also as expected: contractor innovation, schedule acceleration, cost control, and cost certainty regardless of the contract value. The desired benefits of extreme small projects were often the same. However, on several extreme small CM/GC projects, the CM/GC played more of a pure-CM role than ever taking on the general contractor position. In these cases, the agency desired less the contractor's innovation, but more

the contractor's construction managerial expertise and closer relationship with the owner. Table 5 summarizes the benefits found in this study.

5 CONCLUSIONS

Through the DOT manuals content analysis, it can be seen that DOT's are all using similar criteria, questions, and project characteristics in the delivery method selection process. The selection process is a subjective process that requires judgement, experience, and input from multiple project team members. From ACMs, DOT agencies are looking for projects which lend themselves to acceleration, innovation, risk transference, and cost savings. However, agencies do not appear to have formal differences in the processes when deliberating over an extreme small versus extreme large project. The findings of this paper are that extreme small and extreme large D-B projects tend to have differing benefits. Extreme large projects benefit from the expected acceleration, innovation, risk transference, and cost savings. Extreme small D-B projects benefit more from project start acceleration, which is universally supported by agency representative interviews but contradicted in average preparation time (design/procurement) versus D-B-B. It appears that there is a large enough difference in expected results of D-B extreme small and large projects that agencies should consider smaller and larger projects with the understanding of these differing benefits. However, project size does not seem to influence the expected and realized CM/GC benefits with the exception that pre-construction services fees are more difficult to overcome with savings in small projects.

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